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Aircraft accident investigation bureau

Final Report No. 1883 by the Aircraft Accident Investigation Bureau

concerning the accident

to the aircraft Velocity 173 RG, registration HB-YHB,

in the special self-build category

on 10 July 2003

near Würenlingen AG, approx. 40 km west of Zurich

Bundeshaus Nord, CH-3003 Berne

Ursachen

Der Unfall ist darauf zurückzuführen, dass der Pilot beim Versuch einer Notlandung die Kontrolle über das Flugzeug verlor und anschliessend mit dem Gelände kollidierte.

Folgende Faktoren haben zur Entstehung des Unfalls beigetragen:

- Unzweckmässige Konstruktion der Auspuffanlage
- Zu spät verfügbare Informationen für eine umfassende Lagebeurteilung
- Leistungsabfall oder Ausfall des Motors in der Endphase der Notlandung

General information regarding this report

In accordance to the Convention on International Civil Aviation (ICAO Annex 13) the sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

According to art. 24 of the Swiss Air Navigation Law the legal assessment of accident and incident causes and circumstances is no concern of the investigation.

The masculine form is used exclusively in this report regardless of gender for reasons of data protection.

If not otherwise stated, all times in this report are indicated in local time (LT). At the time of the accident the Central European Time (CET) was valid for the area of Switzerland. This CET was equal to the local time (LT). The relation between LT, CET and UTC is: LT = CET = UTC + 2 h.

The german-language version of this report is authoritative.

The Aircraft Accident Investigation Bureau (AAIB) of Switzerland would like to thank the authorities and other organizations for the given support throughout the investigation.

Final Report

Owner and keeper	Private
Aircraft type	Velocity 173 RG
Country of manufacture	USA (kit), assembly in Switzerland
Registration	HB-YHB
Location	In the Neuguet, north of Würenlingen AG
Date and time	10 July 2003, 11:25 LT

General

Brief description

On 10 July 2003 at 10:28 LT, the pilot, in his self-built aircraft, Velocity 173 RG, of the special self-build category, registration HB-YHB, took off from Grenchen aerodrome on a private VFR flight to Straubing in the German Federal Republic. Apart from the pilot, there was one passenger in the aircraft. Approximately half an hour after take-off, the pilot informed “Zurich Information” that he had a problem with the electrical system and that he intended to return to Grenchen. At this time, the aircraft was over southern Germany.

In response to an instruction from “Zurich Information” to reset the ATC transponder to code 4253, the pilot reported at 11:08 LT that his ATC transponder had failed. A further instruction from the assistant air traffic controller (ATCO) to report at waypoint Trasadingen was not confirmed by the pilot.

The aircraft was later observed by several eyewitnesses in flames and trailing smoke before crashing in a maize field just north of Würenlingen AG. The pilot and his passenger were fatally injured. The time of the accident was indicated by eyewitnesses as 11:25 LT.

Investigation

The accident took place on 10 July 2003 at 11:25 LT. At 11:26 LT an eyewitness called the operations centre of the police headquarters of the Aargau cantonal police and reported a small aircraft crashing in the vicinity of Würenlingen.

The investigation was launched on the same day by the Federal Aircraft Accident Investigation Bureau, in cooperation with the cantonal police of Aargau.

The accident is attributable to the fact that the pilot during an attempt to make an emergency landing lost control of the aircraft and subsequently collided with the terrain.

The following factors contributed to the genesis of the accident:

- unsuitable construction of the exhaust system
- too late available information for a comprehensive assessment of the situation
- a drop in power or engine failure in the final phase of the emergency landing

1 Factual Information

1.1 Pre-flight history and history of flight

1.1.1 Pre-flight history

Aircraft HB-YHB was built by the keeper and pilot himself, together with a team of helpers. It was a construction kit with some prefabricated components and detailed construction instructions. The project was monitored by the "Experimental Aviation of Switzerland" (EAS) association.

The first flight and a considerable part of the flight testing programme were carried out by a retired test pilot. The flight test programme was documented. The test pilot was also responsible for giving the builder flight training instructions on the Velocity, HB-YHB.

Aircraft HB-YHB had its first accident on 4 August 1999. During a precautionary landing after a drop in engine power immediately after take-off, the aircraft rolled off the end of the runway. In the process, the nosewheel and propeller were damaged. The aircraft remained on the ground for 20 months. The repair was documented. At the time the AAIB produced a summary report in which a loose air intake hose was quoted as the cause.

After damage to the landing gear in June 2002, the aircraft was again out of operation for almost a year.

According to the logbook, twenty-two fairly short flights were made by HB-YHB between May and July 2003. The last two flights before the accident took place on 6 July 2003. They were made from Grenchen to Locarno and back and each lasted 55 minutes. These were not made by the builder.

1.1.2 History of flight

On 10 July 2003 at 10:28 LT, the pilot took off in his self-built aircraft, Velocity 173 RG, registration HB-YHB "Experimental", from Grenchen aerodrome (LSZG) on a private VFR flight to Straubing (EDMS) in the German Federal Republic, in order to perform noise level measurements on the aircraft there. Apart from the pilot, there was one passenger on board the aircraft. At 10:38:46 LT, the pilot reported to "Zurich Information" that he was enroute from Grenchen via waypoints Trasadingen - Wengen - Walda to Straubing in Germany and that he was at an altitude of 3500 ft QNH over Oensingen. "Zurich Information" then instructed the pilot to avoid the controlled airspace around Zurich (TMA and CTR), to maintain a maximum altitude of 3000 ft QNH and to report again at Trasadingen VOR. At 10:39:15 LT, the pilot confirmed that he would descend to 3000 ft QNH and that he would report at Trasadingen VOR.

At 10:51:41 LT, the pilot reported to "Zurich Information" that he was passing over Trasadingen at an altitude of 3000 ft QNH. A few seconds later, "Zurich Information" instructed the pilot to set the ATC transponder code to 4253. The pilot answered with: "*four two five three is coming*".

At 11:06:24 LT, the pilot again reported to "Zurich Information" and informed them that he had a problem with the electrical system and that he would intend to return to Grenchen. He reported that he was presently at 5500 ft QNH, but would again descend to an altitude of 3000 ft QNH. At this time, the aircraft was over southern Germany. Half a minute later, "Zurich Information" informed the

pilot that the flight plan would be changed and at the same time instructed the pilot to reset the ATC transponder to code 4253. A little latter, at 11:08:06 LT, the pilot reported that his ATC transponder had failed but that he would descend to 3000 ft QNH.

At 11:08:11 LT, the "Zurich Information" assistant ATCO confirmed with "*ah roger*" that he had received the pilot's message and instructed him to report at waypoint Trasadingen. This instruction was not confirmed by the pilot.

The aircraft was later observed by several eye witnesses, in flames and trailing smoke before crashing in a maize field just north of Würenlingen AG. The pilot and his passenger were fatally injured. The time of the accident was indicated by eye witnesses as 11:25 LT.

The "Zurich Information" assistant ATCO tried a further three times to contact HB-YHB (at 11:34:36 LT, 11:34:49 LT and 11:36:20 LT), but without getting any response.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	1	1	---
Seriously injured	---	---	---
Slightly injured or uninjured	---	---	

1.3 Damage to aircraft

Aircraft HB-YHB was destroyed by the impact and the fire which broke out.

1.4 Other damage

200 – 300 m^2 of maize was damaged by the crash, the subsequent fire and the recovery activities.

1.5 Personnel information

1.5.1 Pilot

Person	Swiss citizen, born 1945
Licence	Private pilot's licence, issued by the FOCA on 06.10.1978
Ratings	VFR
Registered aircraft types	C150, C172, C182, Velocity

1.5.1.1 Flying experience

Total flying experience	446 hours
on powered aircraft	446 hours
on the accident type	43 hours
during the last 90 days	9 hours

1.5.2 Passenger

Swiss citizen, born 1948.

The passenger had no flying licences or experience.

1.6 Aircraft information

1.6.1 Aircraft HB-YHB

Aircraft type	Velocity 173 RG
Characteristics	Single-engined, four-seater mid-wing aircraft with canard, retractable landing gear and adjustable propeller
Kit manufacturer	Velocity Inc., Sebastian, Fl 32958 USA
Builder	Self-build by the keeper according to the manufacturer's documentation
Year of construction / serial number	1998 (completion) / DMO 078
FOCA acceptance test	Airframe 07.12.1998, IERA 17.12.1998
Date of registration	04.03.1999
Airworthiness certificate	Provisional certificate, issued on: 08.03.99, last extension (No. 4), issued on: 10.02.03, valid until 31.12.03
Certification	VFR daylight, non-commercial transport, for flights according to flight testing programme
Noise certificate	Pending
Operating hours	105 hours
Engine	Lycoming, IO-360-A3B6D, SN L-16677-51AC
Fuel	AVGAS 100 LL
Propeller	Mühlbauer, MTV-12-B-230/LD168-101, three-blade, constant speed
Drive type	Pusher

1.6.2 Mass and centre of gravity

The take-off mass on take-off was calculated as follows:

Zero fuel weight (ZFW)	673 kg	
Fuel (262 l[1] / 0.71)	186 kg	
Occupants (2 x 85 kg, estimated)	170 kg	
Take-off weight (TOW)	1029 kg	(MTOW 1090 kg)

The centre of gravity on take-off was calculated as follows:

	mass (lbs)	arm (inches)	moment (in lbs)
Zero fuel weight (ZFW)	1483	128.07	189 928
2 occupants, each 85 kg	375	79.13	29 674
Fuel 186 kg	410	124.01	50 806
Take-off weight (TOW)	2268	119.22	270 408

On take-off, the mass and centre of gravity were within the permitted limits.

1.6.3 Engine

The aircraft was equipped with an air-cooled four-cylinder boxer engine with fuel injection system, in pusher configuration, type LYCOMING IO-360.

The engine, LYC IO-360-A3B6D, SN L-16677-51AC, was the subject of a basic overhaul in 1996. It was installed in HB-YHB in March 1999.

The mandatory Textron Lycoming service bulletin (SB) 525 (high pressure fuel pump) was carried out by a licensed maintenance company in the German Federal Republic before the engine was put into service.

During the downtime due to repairs after the accident on 4 August 1999, mandatory SB No. 201E was carried out by a licensed maintenance company.

On 5 May 2003, the 100 hour checks were carried out on the engine and propeller by a maintenance company licensed by the FOCA. During this downtime, four airworthiness directives were carried out on the engine. With regard to the situation encountered in the engine compartment, the following points were made, among others (translation from German):

"*The entire exhaust system including silencer was located inside the engine compartment. Furthermore, the unprofessional installation of the exhaust system was striking (no aircraft standard clamps used). The engine compartment was packed with exhaust pipes.*"

[1] At Grenchen, the aircraft was refuelled with 180 l. Out of experience one can assume that after this the aircraft had full tanks. According our calculations the centre of gravity had moved forward only marginally after one hour flight time.

1.6.3.1 Engine monitoring instrument

Aircraft HB-YHB was equipped with an electronic engine monitoring instrument VM 1000. Among other things, this indicated the engine charge pressure, oil pressure and temperature, fuel pressure, CHT and EGT.

1.6.3.2 Camera in the engine compartment

A camera was installed for additional monitoring of the engine compartment. However, this always failed after approximately 15 minutes due to excessive high temperatures. The camera was not part of the construction kit and was not submitted to the EAS for approval.

1.6.3.3 Engine lubrication system

An oil cooler was installed in the aircraft's nose to cool the engine oil. This meant that the engine oil had to be pumped to the nose via a system of pipes and back again. The arrangement described led to high oil temperatures, primarily when the aircraft wasn't moving or at a low airspeed in connection high engine power (in a climb). A modification which was made during repairs in 1999 brought no substantial improvement. Thus, the flight testing programme had to be aborted on various occasions owing to a high oil temperature.

1.6.4 Propeller

The propeller on HB-YHB was an adjustable three-blade propeller, type MTV-12-B-230/LD168-101, manufactured by Mühlbauer. The pusher propeller had a diameter of 168 cm and was of wood-composite construction.

1.6.5 Fuel system

Essentially, the fuel system consisted of a Bendix RSA 5 injector, a mechanical diaphragm pump (engine-driven pump) on the engine, an electrical auxiliary fuel pump, two 30-gallon wing tanks and a 6-gallon fuselage tank. The fuel pressure was indicated on the electronic engine monitoring instrument. The electrical pump served as a back-up for the mechanical diaphragm pump.

No switching system was provided for the fuel supply, i.e. the engine was supplied simultaneously with fuel by both wing tanks via the fuselage tank.

Inside the engine compartment, the flexible lines were provided with fire sleeves and were additionally wrapped up with insulating bandages. The injector lines to the injection nozzles were also provided with fire sleeves. Thin stainless steel sheets were positioned at various points for air guidance. These served the canalised ventilation respectively the selected cooling of individual components. Due to the extensive destruction, accurate determination of the positioning of the lines was no longer possible.

1.6.6 Exhaust system

On the exhaust system specified by the manufacturer, the heat of combustion is extracted from the engine compartment via the shortest possible route. However, this arrangement does not allow the very stringent noise regulations applicable in Switzerland to be met.

The exhaust system of HB-YHB consisted of stainless steel compensators[2], mounted directly on the exhaust flanges, leading on both sides to a Liese silencer. These in turn led to a common exhaust muffler mounted above the engine block. The muffler was equipped left and right with outlet pipes which were routed to the open air through the engine cowling. Various components of the exhaust system were wrapped with heat-protection bandage.

Adding the Liese silencer and muffler to the exhaust system was undertaken as a major alteration. This alteration took place after the issue of the FOCA approval in December 1998.

For the installation of a silencer system the builder made an application for alteration to the EAS. This major alteration was examined after its implementation by an EAS adviser on 24 March 2003. In his report he made some conditions to be fulfilled in part before and in part after granting the approval. According to a statement by the EAS neither the fulfilment of the conditions nor the accomplishment of a post inspection were documented. According to the EAS the approval for experimental aircraft was in the responsibility of the FOCA at that time. Therefore the EAS assumed that the respective reports and documents would have been sent directly to the FOCA.

In a letter dated 26 February 2004, the FOCA stated that it had had no knowledge of this alteration.

The FOCA was of the opinion that the builder had to deliver the required documents for technical verification, among others the measurement of the silencer system back pressure, to the EAS before carrying out any further flight. At that time the approval of major alterations was in the responsibility of the FOCA.

1.6.7 Electrical system

The electrical system consisted essentially of an alternator driven by a V-belt with an integrated regulator, a 12V/30Ah battery and a power distribution system with circuit breakers. By means of a master switch, the main bus and the avionics bus could be supplied with power. During engine start-up, the avionics bus could be isolated from the main bus by a separate switch. The excitation voltage for the alternator was connected via the alternator switch.

1.6.8 Avionics system

VHF-COM	1 King KY-197A
VHF navigation	1 King KN-53
GPS navigation	1 King KLN-35A
ATC transponder	1 King KT-76A, 1 altitude encoder - Ameri King AK 350
Intercom panel	1 Garmin GMA 340
Emergency locator transmitter	Artex ELT

[2] A bellows made from stainless steel sheet

1.6.9 Aircraft maintenance

According to the aircraft flight manual, a check had to be carried out every 25 hours.

On 18.05.01, at 27.1 hours / 71 landings, the 25 hour check was carried out by a licensed maintenance company.

On 31.10.01, at 45 hours / 112 landings, a further 25 hour check was carried out by a licensed maintenance company.

On 05.05.03 a 24-month check was carried out on the transponder by a licensed maintenance company.

No 25-hour check after 75 hours of operation was entered in either the logbook or the technical documentation.

The 100 hour check was carried out on 25.05.03 at 92.5 hours / 220 landings. The check was signed, without a name being indicated.

Entries are missing in the FOCA airframe maintenance documentation.

1.6.10 Flight testing programme

On the occasion of the flight test programme, which was carried out by a test pilot, there was a complaint about the calibration of the airspeed indicator. Also, there was a complaint that the stall speed was too high. From the available documentation, the degree to which the problems with calibration of the airspeed indicator had actually been rectified by the time of the accident, was not entirely clear. Vortex generators were fitted to the canard in the second half of 2001 to improve the stall characteristics.

The aerodynamic behaviour of the aircraft was generally assessed as satisfactory. The trailing edge of the ailerons was widened to improve their effectiveness at low speeds.

1.6.11 Noise level measurements

Noise level measurements were performed in June 2002 and May 2003 by EAS in Grenchen. On both occasions the requirements were not met.

1.6.12 Flight manual for operation of HB-YHB

In the flight manual drafted by the builder and approved by the FOCA, which was available to the investigation, the date, revision status and proofs of sources were missing.

1.7 Meteorological information

1.7.1 General weather situation according to information from MeteoSwiss

An unpronounced pressure distribution over Europe determined the weather in Switzerland. Dry air was being fed at altitude from the north-west, and this additionally stabilised the atmosphere.

1.7.2 Weather at the time and location of the accident

The following information on the weather at the time and location of the accident is based on spatial and chronological interpolation of the observations of different weather stations. This interpolation was carried out by MeteoSwiss:

Weather/cloud	1/8 cumulus at approx. 5000 ft AMSL, above that 4-6/8 cirrus	
Visibility	about 15 km	
Wind	variable, 2 to 5 knots	
Temperature/dewpoint	24 °C / 12 °C	
Atmospheric pressure	QNH LSZH 1020 hPa, QNH LSZG 1020 hPa	
Risks	none detectable	
Position of the sun	Azimuth: 125°	Elevation: 55°

1.8 Aids to Navigation

The flight was taking place under visual flight rules (VFR). The conditions of the navigation aids on the ground was therefore not of significance in connection with the accident.

1.9 Communication

Radiocommunication took place with “Zurich Information” on frequency 124.700 MHz. Comprehensibility was good until the radio link was interrupted by HB-YHB at 11:08:06.

1.10 Aerodrome information

Not applicable

1.11 Flight recorders

Not prescribed and not installed.

1.12 Wreckage and impact information

1.12.1 Site of the accident

The site of the accident was approx. 1.5 km to the north of Würenlingen AG in the “Neuguet” area, in the middle of a maize field. The wreck of the aircraft was approximately 300 m to the east of the main road between Siggenthal Station and Döttingen and accessibility was relatively good for the rescue services (cf. Annex 1).

The maize field and the locality were searched systematically for pieces of aircraft wreckage by the attending police and rescue services. The items which were found were limited to the actual crash site.

After the recovery work had been completed, the topsoil in the area of the crash site was removed and disposed of.

Coordinates: 661 110 / 266 190, approximately 360 m/amsl, national map of Switzerland, Sheet No. 215, Baden

1.12.2 The wreck

Since the aircraft crashed at a steep angle, the debris field was confined to a relatively small circumference.

The structure was badly damaged by fire. The fireproof bulkhead and the main landing gear components were still attached to the engine, which was separated from the fuselage. The fuselage itself burned out with all of the interior and with the entire cockpit, so practically only the laminate fabric remained. The canard wing pair was largely preserved in its structure, but also exhibited traces of fire (cf. Annex 2).

Only the left main wing tip was not affected by the fire.

The serious effects of fire on the wreck of the aircraft are explicable by the fuel which ignited on impact. Forensic differentiation between the primary traces of fire, which originated in flight, and secondary fire damage, caused by the fire on the ground, was not possible.

1.12.2.1 Findings on the engine after the accident

From the molten aluminium parts found on the engine, it was possible to determine that the engine finally came to rest bottom up. All combustible material around the engine had been burned away (cf. Annex 3).

On the top of the engine, the fuel pipe to the fuel divider was still present, as were the four pipes leading from the divider to the cylinders. The divider itself had melted off the motor block, with the exception of the four mounting screws (cf. Annex 3).

A large part of the sump under the engine had melted, causing all the engine oil to leak out and combust. The oil lines mounted on the engine in the factory were all screwed on tight.

The insulation material of the electrical cables, which led to the starter and the burnt-out alternator, had been completely burned away.

The engine was dismantled in the workshop of a licensed maintenance company. In the process, it was established that with a very high degree of probability, it was at a standstill at the time of impact.

1.12.2.2 Findings on the propeller after the accident

The hub of the propeller was intact. Two blades were completely missing. They had burned away up to the blade mount. No fragments of the missing propeller blades were found in the close vicinity of the accident site.

1.12.2.3 Findings on the emergency locator transmitter after the accident

The emergency locator transmitter (ELT) was destroyed by the high temperatures.

1.13 Medical and pathological information

An legal medical examination was performed on both occupants. DNA analysis had to be performed for purposes of identification. The examination showed that the injuries suffered in the accident led to immediate death. The toxicological

examination for alcohol, medications and drugs were negative. There was no evidence of existing diseases of the pilot.

The autopsy findings exclude the presence of smoke in the cockpit or external injury to the occupants during the flight.

1.14 Fire

After the crash fire broke out; it could be extinguished by the local fire brigade from Würenlingen. Fire-fighting operations lasted approximately 15 minutes.

1.15 Survival aspects

The accident was not survivable.

1.16 Test and research

None

1.17 Organizational and management information

1.17.1 Approval of self-build aircraft

In Switzerland self-build aircraft constructors are grouped together in an association registered under the name “Experimental Aviation of Switzerland” (EAS). This supports the constructors in the areas of administration, planning, supervision of construction, ground checks, flight testing and approval by the Federal Office for Civil Aviation (FOCA).

FOCA document No. MZ-275.001 “Lufttüchtigkeitsanforderungen für Eigenbauluftfahrzeuge” (Airworthiness Requirements for Self-Build Aircraft) describes, in Annex 2, the FOCA-EAS agreement concerning approval of self-build aircraft. This directive in turn is based on the Decree concerning the airworthiness of aircraft – VLL (748.215.1), article 10, para. 2.

The process described below makes no claim to completeness, but is intended to provide a rough outline of the steps required to obtain approval.

Before construction begins, the builder’s premises, equipment and capabilities are verified by an EAS construction consultant with experience of self-build aircraft. Depending on the requirements, EAS engineering specialists will be requested in this phase to make an assessment of the project.

With a view to quality control, the EAS construction consultant performs supervision of construction during the construction phase. In the process, the latter also checks the correspondence of the aircraft under construction with the approval basis submitted by the builder (construction plans, drawings, construction instructions, parts lists, etc.). Deficiencies are logged by the construction consultant and must be corrected by the builder. If the builder is obliged to deviate from the construction documents, he must justify this and if necessary obtain approval. The builder himself is responsible for construction and for the performance of the work.

The builder must provide the necessary documentation for proving compliance with the airworthiness requirements. EAS specialists check this for completeness and applicability and handle the administrative element. Proof of compliance with airworthiness requirements for self-build aircraft is in principle based on the procedures applicable to aircraft in the standard category. However, it may be provided in a simplified form for self-build aircraft (cf. FOCA Document No. MZ-275.001, Annex 2, Point 1).

Basis for airworthiness requirements: VLL 748.215.1, JAR-VLA, JAR-VLR, JAR-23, JAR-27, JAR-E, JAR-P, FOCA Doc. MZ-275-001

Final testing by an expert commissioned by the FOCA constitutes a milestone on the road to approval. Before a date is agreed with the latter, an internal EAS "final check" ensures that:

- supporting documentation, including any deviations from the original, is complete and in order.
- checklists, provisional flight manual and provisional maintenance manual are present
- test reports for weighing, engine static thrust measurement (in the case of powered aircraft), fuel flow measurement (in the case of powered aircraft), load tests, air speed indication, etc. are present
- the electric power load balance sheet has been produced
- the radio licence has been registered with OFCOM
- an assessment has been made as to whether noise level measurements are necessary (basis: Decree on aircraft emissions – VEL [748.215.3], ICAO Annex 16, Chapter 10).

In the case of a positive result for the final test (the acceptance test) by the FOCA experts and a corresponding report back to the Office, the FOCA enters the aircraft in the aircraft register, issues a provisional airworthiness certificate and specifies the approval area. Conditions for operation are also entered in the aircraft flight manual (AFM). This certificate entitles the builder to carry out a flight testing programme. Performance of the flight testing must take place on the basis of the FAA Flight Test Guide, AC 23-8A, (cf. FOCA document No. MZ-275.001, Annex 2, Point 2.7).

Prior to the flight test phase respectively prior to the first flight the attendance at an EAS safety seminar is mandatory for any builder. In addition an EAS authorised flight consultant is made available to the builder. In a safety assessment the builder's flight experience will be assessed and rated. Additionally, measurements to ensure a successful first flight and subsequent test flights will be laid down. The purpose of the flight test programme is to fly and/or verify the data required for the definitive aircraft flight manual (stall speed, cruise performance). The data acquired are logged and recalculated by the EAS.

For aircraft which have to undergo noise measurements, the EAS Noise Measuring Group offers sound level measurements. A noise certificate is issued by the FOCA when the measurements have been completed successfully.

Once the flight test programme has been concluded successfully, the definitive airworthiness certificate may be requested from the FOCA.

1.17.2 EAS activities in connection with the construction of HB-YHB

Activities, construction follow-up

RSA[3] notification	March 1994
Commencement of construction	March 1995
Canard load test	November 1995
Wing load test and body shell inspection	December 1995
RSA final inspection	August 1998
FOCA acceptance	December 1998
Weighing, EAS assessment	February 1999

Additionally, the project was accompanied by an EAS advisor during the whole building phase.

1.17.3 Maintaining of airworthiness after approval

FOCA document No. MZ-275.001 "Lufttüchtigkeitsanforderungen für Eigenbau-luftfahrzeuge" (Airworthiness Requirements for Self-Build Aircraft) describes the requirements as follows, in Annex 2, Point 3:

"*Maintenance, as well as major alterations / repairs must be carried out in accordance with the legal requirements (VLL, SR 748.215.1; FOCA regulations, etc.). The configuration must at all time correspond to the latest approved conditions and with the documentation in the technical files*".

1.17.3.1 Repairs to the aircraft

The keeper of a self-build aircraft decides whether a repair is minor or major on the basis of a checklist from the EAS approval office.

Major repairs[4] (possibly after an accident) must be notified to the EAS approval office by the keeper of the aircraft. This office examines the documents and decides on the basis of TM-R 02.020.60 and AC 43.13.1B about the implementation of the repair. The procedure for major repairs is similar to that for the construction of the aircraft. Depending on the type and scope of the repair, it may be necessary to carry out further test flights. For these, the aircraft may under certain circumstances have to be reclassified with the status of "provisional airworthiness certificate". Major repairs are notified to the FOCA when they are completed and the modified documents are to be submitted.

[3] The name of the association "Réseau du Sport de l'Air Suisse" (RSA) was changed on 3 March 2001 to "Experimental Aviation of Switzerland" (EAS).

[4] Major repairs are those which may have an effect on the structural or aerodynamic properties of an aircraft. They require analysis by specialists and must be documented.

1.17.3.2 Modifications to the aircraft

In the EAS document "Beschreibung der Prozessabläufe im Rahmen eines Luftfahrzeug Projektes - Description of the procedures as part of an aircraft project", the procedure for modifications to the aircraft is described as follows:

"*The approval office examines the documents for an alteration and decides on the basis of TM-R 02.020.60 whether it is a minor or major alteration*[5]*. Minor alterations may be carried out informally according to the specification and registered by the constructor. In the case of a major alteration already carried out on another aircraft of the same type, the simplified procedure (documentary proof already available) may be implemented. In the case of a licensed aircraft, the airworthiness certificate is lodged with the approval office during the alteration phase. For the alteration, the project is transferred to a normal construction process; this may, according to the prescription of the approval office, lead to subsequent test flights and further sound level measurements. To this end, a provisional airworthiness certificate must be applied for from the FOCA in the case of new test flights*.

After completion of major alterations, a notification will be sent to the FOCA, along with submission of the description of the alteration plus the modified documents (AFM, equipment lists, etc.), where applicable with substantiation documents and the Major Alteration Form (EAS 11.40).

When the major alteration has been completed, the approval office signs for it, ensures it is entered into the corresponding documents and updates the database. The airworthiness certificate which may have been lodged is returned to the keeper or an application is made for a new one."

1.17.3.3 Maintenance of the aircraft

The maintenance plan is approved as part of the approval. The keeper of the aircraft is responsible for complying with the checks which are to be performed periodically.

The Decree concerning the airworthiness of aircraft – VLL (748.215.1), article 33 – allows the keeper of a self-built aircraft considerable leeway with regard to the performance of maintenance work.

1.17.3.4 Periodic inspection

The main purpose of a periodic inspection is to ensure compliance of the technical documentation with the approved configuration of the aircraft. Attention is also paid to the technical condition of the aircraft. On-board papers are also checked for correctness. Inspections are carried out by specially nominated EAS examiners. These are audited by the FOCA. An attempt is made to adhere to a 2-year inspection cycle. Rectification of complaints must be reported to the FOCA.

[5] Major alterations are those which may have an effect on the structural or aerodynamic properties of an aircraft or its operation.

1.17.4 Use and operation of self-build aircraft

Self-build aircraft are intended for personal use; commercial use is not permitted.

1.18 Additional information

1.18.1 Eye witnesses

Eye witnesses observed the course of events of the accident from various positions around the site of the crash. The statements permit a relatively accurate reconstruction of the flight path and events immediately before the crash (cf. Annex 1).

Statements which correspond closely to each other were included in the analysis.

2 Analysis

2.1 Technical aspects

2.1.1 General

From the outset the builder had difficulties achieving the noise limits for the HB-YHB set by the FOCA. Several noise level measurements conducted in Grenchen produced a negative result.

From the heat insulation bandages, heat shields and fire sleeves which were found, it must be assumed that the builder of HB-YHB had to contend with serious thermal problems in the areas of the engine/exhaust system and fuel supply. Several possibilities were tested on the silencer system without leading to success. More and more insulating material was used in an attempt to combat the damaging effects of heat.

The builder's difficulties to comply with the strict noise abatement regulations in Switzerland may have led him to the installation of a silencer system inside the engine compartment. Nevertheless, the noise certificate was still pending and this was a prerequisite for a definitive airworthiness certificate.

Aircraft with pushers generally tend to have more problems with noise emissions. The pilot and builder of the aircraft hoped to find solutions to his noise problems in Straubing.

2.1.2 Engine

With a view to finding explanations of why a fire broke out in flight, the investigation focused on the fuel system, engine lubrication and the electrical components around the engine. Fire breaking out in the front part of the fuselage or in the aircraft cabin was assessed as improbable.

On the top of the engine, the fuel pipe to the divider was still present, as were the four pipes leading from the divider to the cylinders. The latter were covered with fire sleeves. The divider itself had melted. Stereomicroscopic examination of the fuel pipes revealed no indications of damaged areas. No conclusive statements can be made about how sound the unions were. It can be assumed that these were checked at the time of the 100 hour check two months prior to the accident.

The fuel divider with its rubber-like diaphragm was located directly above the engine block and in the vicinity of the silencer. In view of the presumed considerable heat radiated from the exhaust system, the potential behaviour of the diaphragm to heat up was subjected to critical consideration. Analysis of a diaphragm of the same type revealed that it was composed of a fuel-resistant fluorsilicone rubber. In addition, the mass loss of this material with increasing temperature was determined. On the basis of the result, it could not be excluded that the thermally damaged fuel divider diaphragm was no longer able at some point to withstand the fuel pressure, allowing fuel to leak and ignite on the hot parts of the engine, the exhaust system or as a result of heat build-up in the engine compartment.

The builder had another temperature-related problem in the area of the lubrication system. Engine oil was pumped to the nose for cooling purposes. There it flowed through the oil cooler and was fed back to the engine. At the time of the repair after the first accident, the oil cooler was repositioned and the cross-sectional area of the air inlet and outlet was increased. Even after this alteration, the oil temperature during training flights increased to such an extent that the flights had to be aborted.

2.1.3 Exhaust system

The choice of exhaust components and materials, particularly the compensators used in the hot area, must be deemed inappropriate according to an expert report. The Liese silencers produced a high exhaust back-pressure. It cannot therefore be excluded that during the flight involved in the accident a crack appeared in a component of the exhaust system and that the hot exhaust gases emerging from it led to the failure of the alternator and subsequently to the fire in the engine compartment.

2.2 History of flight

At 11:06:24 LT, the pilot reported on the “Zurich Information” frequency that he had problems with the electrical system and intended to return to Grenchen. The assistant ATCO then asked the pilot to reset code 4253 on his transponder, to which the pilot responded at 11:08:06 LT that his transponder had failed. In reality, however, the cited code had already disappeared from radar at 11:03:16 LT.

The pilot’s report at 11:08:06 LT to the effect that his transponder had failed was also the last radio communication sent from HB-YHB.

It is highly probable that the alternator had failed some time before, so that the electrical loads were now being supplied from the battery. As the battery voltage dropped, first the transponder and then a short time later the radio failed. In charged condition, the battery voltage is 12 volts. As a rule, avionics equipment cuts out when the operating voltage drops below 10.0 to 10.5 volts. It remains open whether an electrical short-circuit accelerated the discharging of the battery.

Very probably, overheating caused the alternator to fail. The internal electronic voltage regulator may have been a source of the fault. Another possible source of the fault may have been the failure of the V-belt.

On the return flight to Grenchen, approximately 16 minutes after the final radio contact and after the aircraft had passed over Acheberg, it came into the field of view of several eye witnesses. These reported that the aircraft had passed over Kleindöttingen and then had flown in a southerly direction parallel to the Aare.

Eye witnesses reported that they had first seen white smoke and then heard irregular then spluttering engine noise. The colour of the smoke later changed to grey and then to black. Although the pilot would have found it difficult to see the smoke behind him, he must have had thoughts about an emergency landing at the time of the intermittent engine stall at the latest. The large plain to his left was suitable for this.

According to eye witnesses' statements, the pilot initiated a left turn approximately over Beznau, towards a large field. Almost simultaneously, the aircraft apparently caught fire at the root of the wing, followed by an explosion to the rear. Sources of information in Kleindöttingen 2.5 km away indicated that they had not heard any explosion. Other people in turn described this as more like a muffled bang.

According to eye witness reports, after the explosion-like outbreak of fire the aircraft adopted a steep pitch down and crashed. Some witnesses reported that the aircraft began to spin to the right during the crash.

It cannot be excluded that the pilot reached for the fire cock under his seat beforehand and in the process lost control of the aircraft.

Stalling of the aircraft over the canard as a result of it falling below the minimum speed (stall speed V_s) can neither be excluded, and this would correspond to the stall characteristic of the aircraft[6]. It should be noted that there was no stall warning system on the aircraft. The pilot probably lacked essential prerequisites such as height above ground or engine power in order to re-establish a normal flight condition.

A direct effect of the fire on the pilot is fairly improbable, as the fire was described by eye witnesses as a flame escaping to the rear. On the basis of the autopsy report it may be assumed that neither smoke gases nor particles of soot spread into the cabin.

On the Velocity 173 RG, pitch is controlled via elevators on the canards at the front of the aircraft. It is improbable that this part of the aircraft control system was adversely affected by the events described.

Since none of the eye witnesses questioned had seen anything detach from the aircraft and since nothing was found during the widespread search either, it can be assumed with a high degree of probability that the wings of the aircraft together with the ailerons and rudder had remained intact up to the crash. Whether this also applies to the control linkages cannot be answered conclusively because of the extent of the destruction.

The problems in the electrical system started some 22 minutes before the fire broke out. It therefore appears plausible that these problems were a consequence of the build-up of heat in the engine compartment and were not responsible for ignition of the fuel.

In summary, it can be said that the observed propagation of smoke and the fact that the aircraft could not be landed in the emergency indicate that the fire in the engine compartment spread quickly. All the indications are that a highly combustible material must have been involved. Fuel is the prime candidate. In the case of aviation gasoline, the flashpoint of an inflammable air-gas mixture is around 220 °C. The dark smoke observed by eye witnesses indicates initially incomplete combustion. The previously observed white smoke indicates vaporisation or pyrolysis of the fuel. Engine oil was not in the forefront of the investigation.

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[6] On the Velocity 173 RG aircraft, the canard has a somewhat greater pitch than the main wing. Thus the airflow separates first at the canard.

It is impossible to judge definitively whether a leak on the fuel system occurred as a result of excessive heat, or as the result of incorrect assembly of the components concerned.

Rather, the prime candidates as a source of ignition for the hydrocarbon vapour which was likely generated are an overheated exhaust system or an excessively high temperature inside the engine compartment.

2.3 Human and operational aspects

The pilot's decision to return to Grenchen after the failure of the electrical system was inappropriate. According to the flight manual, in this case the flight should have been terminated as quickly as possible. On the basis of the adopted heading, however, it cannot be excluded that the pilot changed his mind and tried to make for Birrfeld aerodrome.

Although the pilot would have found it difficult to see the smoke behind him, he must have had thoughts about an emergency landing at the time of the intermittent engine stall at the latest.

It has to be assumed that at that point the electronic engine monitoring system had also failed.

During the test phase, fitting rear-view mirrors or another appropriate aid would in the present case have contributed to a better assessment of the situation.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- Aircraft HB-YHB was built by the keeper.
- At the time of the accident, the aircraft had a provisional airworthiness certificate. The noise certificate was still pending.
- Serious thermal problems arose in the area of the engine and the exhaust system. These were aggravated by the attempts to solve the noise problems.
- The major alteration on the silencer system had been examined by the EAS whereby conditions were made. The documents required by the EAS (among others measurements of back pressure), were not submitted to them by the builder.
- Several possibilities for noise reduction were tested on the silencer system without leading to success.

3.1.2 Human aspects

- The pilot was in possession of a private pilot's licence (PPL-A).
- The investigation found no indication of a health problem as cause of the accident.

3.1.3 History of flight

- The aircraft took off at 10:28 LT from Grenchen aerodrome (LSZG) on a private VFR flight to Straubing (EDMS) in the German Federal Republic.
- Good weather conditions prevailed for the flight under visual flight rules.
- Approximately 30 minutes after take-off, the pilot reported problems with the electrical system.
- The pilot decided to return to Grenchen.
- Shortly afterwards, the ATC transponder failed and then radio contact was broken.
- According to eye witness reports, the aircraft crashed at a steep angle at 11:25 LT north of Würenlingen, in a maize field.
- Even before the impact, eye witnesses claim to have seen smoke and fire as well as hearing spluttering engine noises.
- The two occupants of the aircraft suffered fatal injuries.
- The aircraft was destroyed.

3.2 Causes

The accident is attributable to the fact that the pilot during an attempt to make an emergency landing lost control of the aircraft and subsequently collided with the terrain.

The following factors contributed to the genesis of the accident:

- unsuitable construction of the exhaust system
- too late available information for a comprehensive assessment of the situation
- a drop in power or engine failure in the final phase of the emergency landing

4 Measures taken after the serious accident

On 13 December 2005 the FOCA has submitted the following information to the EAS:

„Im Zusammenhang mit dem Velocity Unfall haben wir uns bereits über den nachträglichen Einbau eines ‚fire detection' systems unterhalten. Wir möchten hiermit das weitere Vorgehen wie folgt festhalten:

Ref. Bauvorschrift FAR 23.1203(a)(iii): There must be a means that ensure the prompt detection of a fire in airplanes with engine(s) located where they are not readily visible from the cockpit.

1. Bestehende Amateur-Pusher Flugzeuge in der Schweiz (Long Eze & Vari Eze etc.): es wird empfohlen sämtliche Flugzeuge nachzurüsten;
Einbau eines ‚fire detector' im ‚engine compartment' (cockpit warning light) gemäss FAR 3.1203(a)(iii).
Die EAS wird die Halter entsprechend informieren.

2. Bei Änderungen an bestehenden Amateur-Pusher Flugzeugen (Motorumbau etc.) sowie bei neu einzutragenden Pusher Flugzeugen muss diese Anforderung (Einbau eines ‚fire detection systems') erfüllt werden.

Wir möchten die TK hiermit bitten die betroffenen Halter sobald wie möglich, jedoch bis spätestens 31. März 2006 entsprechend zu informieren."

5 Annexes

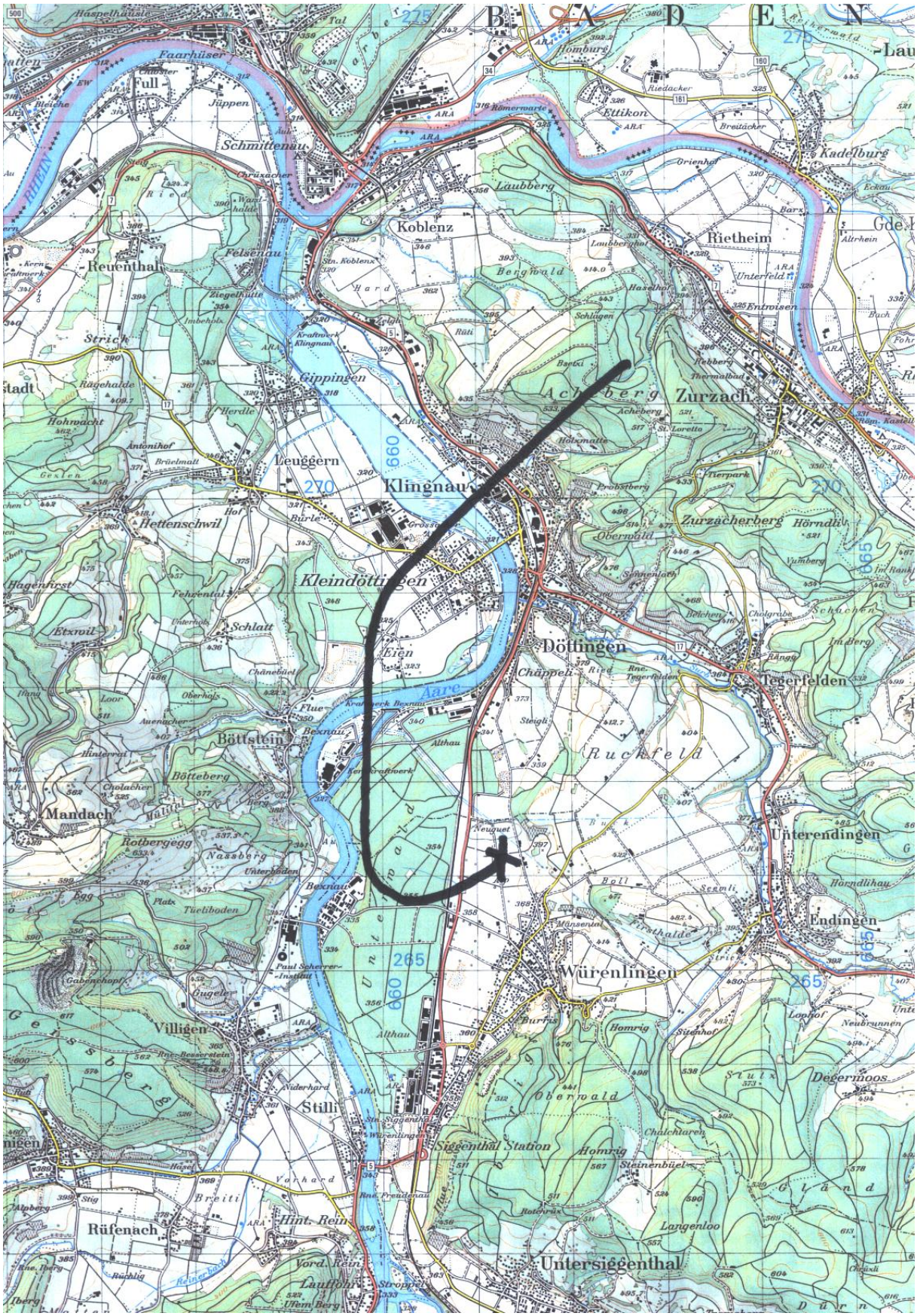
5.1 Flight path

5.2 Photo, aircraft wreck

5.3 Photo, engine, and photo, top of engine

Berne, 6 April 2006 Aircraft Accident Investigation Bureau

Annex 5.1

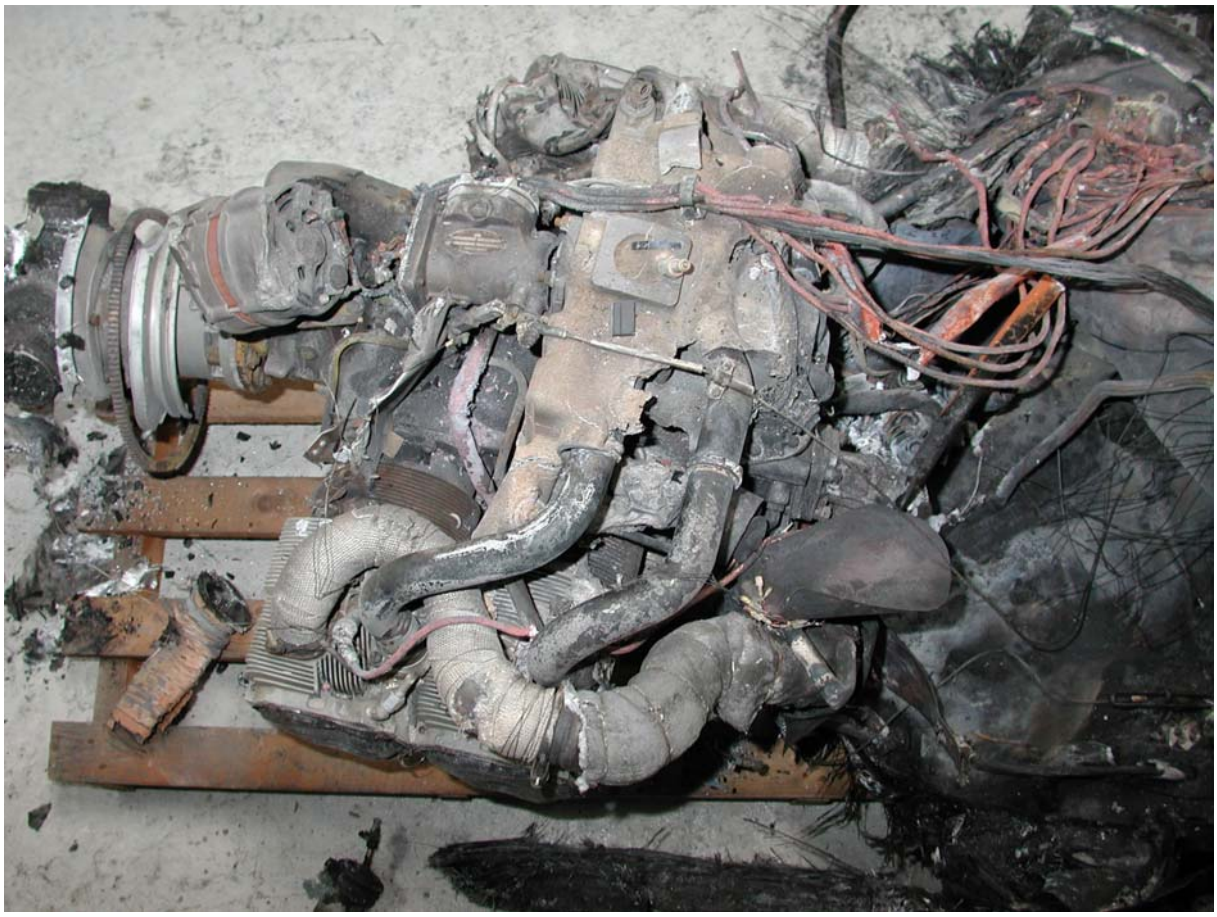


Flight path

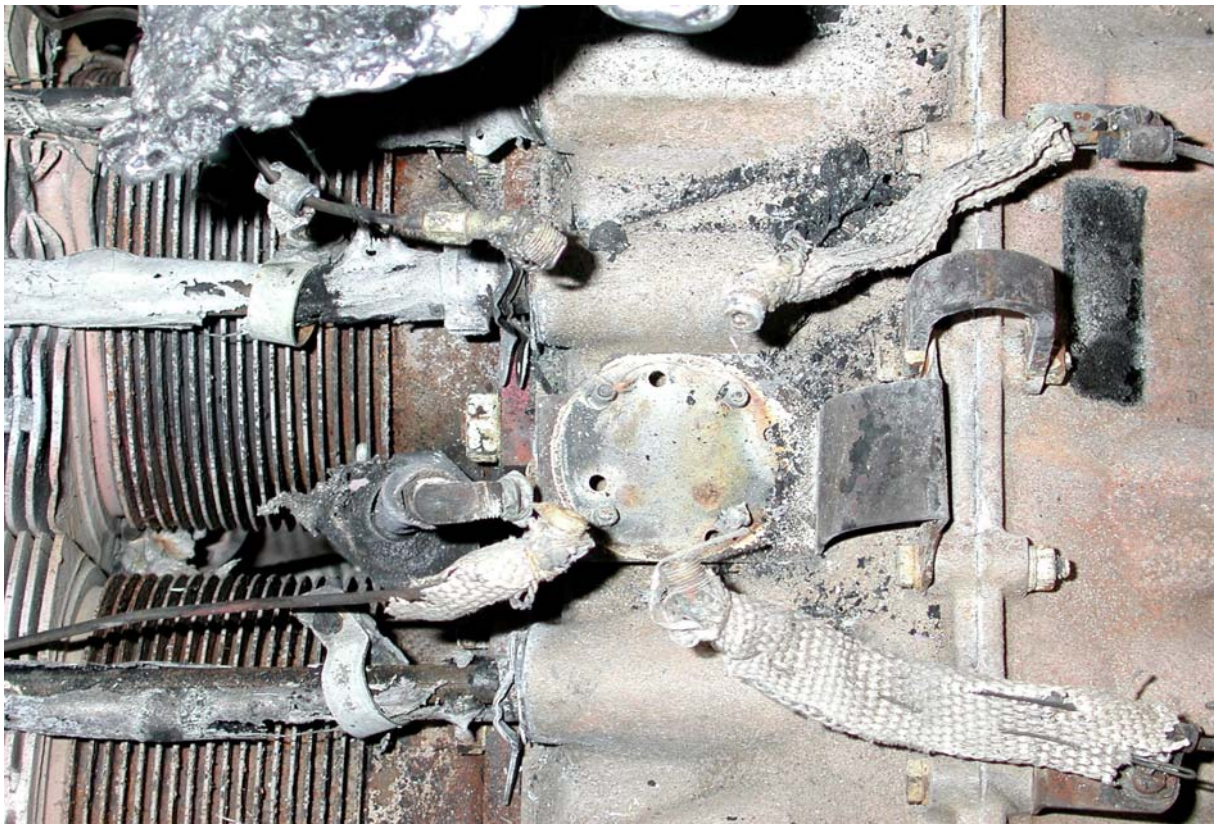
Annex 5.2

Aircraft wreck

Annex 5.3



Engine



Top of engine